

What is claimed is:

1. A magnet type stepping motor comprising

(1) a stator having three-phase stator windings, and $6m$ pieces of stator main pole arranged side by side, where m is an integer and ≥ 1 , the stator windings of one phase being wound around every two stator main poles among the $6m$ pieces of the stator main pole, wherein when the stator windings of one phase are excited with a direct current, m pieces of N pole and m pieces of S pole are formed alternately on the $6m$ pieces of stator main pole, and

(2) a rotor of a cylindrical permanent magnet magnetized in the circumferential direction so as to form $Z/2$ pieces of N pole and $Z/2$ pieces of S pole alternately, where Z is the number of rotor poles.

2. The permanent magnet type stepping motor as claimed in claim 1, wherein the number of rotor poles is set to $m \cdot (12n \pm 2)$ preferably, where n is an integer and ≥ 1 .

3. The permanent magnet type stepping motor as claimed in claim 1, wherein the number of rotor poles is set to $m \cdot (12n \pm 2)$ preferably, and a plurality of pole teeth are

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formed on each of the stator main poles, where n is an integer and ≥ 2 .

4. A permanent magnet type stepping motor comprising (1) a stator having two-phase stator windings, and 12 pieces of stator main pole arranged side by side, the stator windings of one phase being wound around every one stator main poles among the 12 pieces of the stator main pole, wherein when the stator windings of one phase are excited with a direct current, 3 pieces of N pole and 3 pieces of S pole are formed alternately on the 12 pieces of stator main pole, and

(2) a rotor of a cylindrical permanent magnet magnetized in the circumferential direction so as to form $Z/2$ pieces of N pole and $Z/2$ pieces S pole alternately, where Z is the number of rotor poles.

5. The permanent magnet type stepping motor as claimed in claim 4, wherein the number of rotor poles is set to $24n \pm 6$, where n is an integer and ≥ 1 .

6. The permanent magnet type stepping motor as claimed in claim 4, wherein the number of rotor poles is set to $24n \pm 6$, and a plurality

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of pole teeth are formed on each of the stator main poles, where n is an integer and ≥ 2 .

7. A hybrid type stepping motor comprising

(1) a stator having two-phase stator windings, and 12 pieces of stator main pole arranged side by side, the stator windings of one phase being wound around every one stator main poles among the 12 pieces of the stator main pole, wherein when the stator windings of one phase are excited with a direct current, 3 pieces of N pole and 3 pieces of S pole are formed alternately on the 12 pieces of stator main pole, and

(2) a hybrid type rotor consisting of two rotor elements of magnetic material each formed on the circumference thereof with a plurality of pole teeth and of a permanent magnet magnetized in the axial direction held between said two rotor elements.

8. The hybrid type stepping motor as claimed in claim 7, wherein the number of rotor pole teeth is $12n \pm 3$, where n is an integer and ≥ 1 .

9. The hybrid type stepping motor as claimed in claim 7, wherein the number of rotor

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pole teeth is $12n \pm 3$, and a plurality of pole teeth are formed on each of the stator main poles, where n is an integer and ≥ 2 .

5 10. A hybrid inner rotor type stepping motor comprising

10 (1) a stator having three-phase stator windings of U, V, and W, and 12 pieces of stator main pole arranged side by side and extending radially from an annular stator yoke, k pieces of pole tooth being formed on the tip end of each stator main pole, where k is an integer and ≥ 2 , the stator windings of one phase being wound around every two stator main poles among the 12 pieces of the stator main pole, 15 wherein when the stator windings of one phase are excited with a direct current, 2 pieces of N pole and 2 pieces of S pole are formed on the 4 pieces of stator main pole, and

20 (2) a hybrid type inner rotor consisting of two magnetic rotor elements each having a plurality of pole teeth on the outer peripheral surface thereof and a permanent magnet magnetized in the axial direction and held by the two magnetic rotor elements therebetween, 25 the one magnetic rotor element being deviated

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from the other in the peripheral direction by
1/2 pitch of the pole teeth, wherein the number
of the pole tooth is $12k \pm 2$.

11. A hybrid outer rotor type stepping
motor comprising

(1) a stator having three-phase stator
windings of U, V, and W, and 12 pieces of
stator main pole arranged side by side and
extending radially from an annular stator yoke,
k pieces of pole tooth being formed on the tip
end of each stator main pole, where k is an
integer and ≥ 2 , the stator windings of one
phase being wound around every two stator main
poles among the 12 pieces of the stator main pole,
wherein when the stator windings of one phase
are excited with a direct current, 2 pieces of N
pole and 2 pieces of S pole are formed on the 4
pieces of stator main pole, and

(2) a hybrid type outer rotor consisting
of two magnetic rotor elements each having a
plurality of pole teeth on the inner peripheral
surface thereof and a permanent magnet
magnetized in the axial direction and held by
the two magnetic rotor elements therebetween,
the one magnetic rotor element being deviated

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from the other in the peripheral direction by
1/2 pitch of the pole teeth, wherein the number
of the pole tooth is $12k \pm 2$.

12. The stepping motor as claimed in claim
5 10 wherein the pitch of stator magnetic pole
teeth is not larger than the pitch of rotor
pole teeth.

13. A hybrid type three-phase stepping
motor comprising

10 (1) a stator having three-phase stator
windings of U, V, and W, and 12 pieces of
stator main pole arranged side by side and
extending radially form an annular stator yoke,
k pieces of pole tooth being formed on the tip
15 end of each stator main pole, where k is an
integer and ≥ 2 , the stator windings of one
phase being wound around every two stator main
poles among the 12 pieces of the stator main pole,
wherein when the stator windings of one phase
20 are excited with a direct current, 2 pieces of N
pole and 2 pieces of S pole are formed on the 4
pieces of stator main pole, and

(2) a hybrid type rotor consisting of two
magnetic rotor elements each having a plurality
25 of pole teeth on the peripheral surface thereof

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and a permanent magnet magnetized in the axial
direction and held by the two magnetic rotor
elements therebetween, the one magnetic rotor
element being deviated from the other in the
5 peripheral direction by $1/2$ pitch of the pole
teeth, wherein in case that the windings of star
or delta connection are excited, the wiring
direction or the winding direction of the
windings of one phase is reversed to that of the
10 remaining phases.

14. An outer rotor type stepping motor
comprising

a rotor having pole teeth of $12n \pm 2$ on the
inner peripheral surface thereof, where n is an
15 integer and ≥ 1 ,

a stator having three-phase
stator windings of U, V and W, and 12 pieces of
stator main pole arranged side by side and
extending radially outwardly from an annular
20 stator yoke, a plurality of pole teeth being
formed on the tip end of each stator main pole,
and a permanent magnet magnetized in the axial
direction thereof and held between splitted
stator elements, the stator windings of one
25 phase being wound around every two stator main

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poles among the 12 pieces of the stator main pole, each of the windings being wound extending over the two splitted stator elements, wherein when the stator windings of one phase are
5 excited with a direct current, 2 pieces of N pole and 2 pieces of S pole are formed on the 4 pieces of stator main pole.

15. The stepping motor as claimed in claim 14 wherein when the windings of star or delta
10 connection are excited, the winding ends of the windings of U, V and W phases are connected together and the winding direction of the windings of one phase is reversed to that of the remaining phases.

16. The outer rotor type stepping motor
15 as claimed in claim 14, wherein both sides of the rotor are supported by two brackets, respectively, so as to form a gap between the inner peripheral surface of the rotor and the
20 outer peripheral surface of the stator.

17. A driving method of a three-phase annular winding cascade [↓]craw-pole type stepping motor

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comprising (1) a rotor consisting of a
cylindrical magnet magnetized in the
circumferential direction so as to form M
pieces of N pole and M pieces S pole alternately,
5 where M is an integer and ≥ 2 , and (2) a stator
having annular three stator units arranged in
the axial direction of the rotor concentrically
with the rotor axis, each of said stator unit
consisting of two opposite stator cores having
10 craw poles extending axially on the inner
peripheral surface thereof, and of one of three
stator windings of U, V and W phases held between
said two stator cores, said windings of U, V and
W phases being arranged in this order in the axial
15 direction, said craw poles being separated by
 $180^\circ / M$ from one another and magnetized by
said stator winding in opposite polarities
alternately, said three stator windings being
connected to form a star or delta connection,
20 adjacent craw poles magnetized by the stator
windings of U phase and V phase are deviated
by $60^\circ / M$ from each other in the
circumferential direction, and adjacent craw
poles magnetized by the stator windings of V
25 phase and W phase are deviated by $60^\circ / M$ from

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each other in the circumferential direction,
said annular stator windings being excited so
that a magnetic flux generated by the annular
stator windings of one phase in the axial
5 direction becomes always opposite to that by
annular stator windings of the other phase,
in case of two phase exciting driving.

18. A driving method of a three-phase
annular winding cascade crawl-pole type
stepping motor comprising

a rotor consisting of a cylindrical
magnet magnetized in the circumferential
direction so as to form M pieces of N pole and
M pieces S pole alternately, where M is an
15 integer and ≥ 2 , and

a stator having annular three stator
units arranged in the axial direction of the
rotor concentrically with the rotor axis each of
said stator unit consisting of two opposite
20 stator cores having crawl poles extending
axially on the inner peripheral surface thereof,
and of one of three stator windings of U, V and
W phases held between said two stator cores,
said windings of U, V and W phases being arranged
25 in this order in the axial direction, said crawl

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poles being separated by $180^\circ / M$ from one another and magnetized by said stator winding in opposite polarities alternately, said three stator windings being connected to form the star or delta connection, adjacent crow poles magnetized by the stator windings of U phase and V phase are deviated by $120^\circ / M$ from each other in the circumferential direction, and adjacent crow poles magnetized by the stator windings of V phase and W phase are deviated by $120^\circ / M$ from each other in the circumferential direction, wherein the magnetic flux generated by annular stator windings of one phase in the axial direction becomes always the same to that generated by the other annular stator windings of the other phase adjacent to said annular stator windings of said one phase, but a magnetic flux generated by the annular stator windings of one phase in the axial direction becomes always opposite to that generated by the annular stator windings of the other phase which is not adjacent to said annular stator windings of said one phase, in case of two phase exciting driving.

19. A driving method of a three-phase

annular winding cascade crawl-pole type stepping motor comprising

a rotor consisting of a cylindrical magnet magnetized in the circumferential direction so as to form M pieces of N pole and M pieces S pole alternately, where M is an integer and ≥ 2 , and a stator having annular three stator units arranged in the axial direction of the rotor concentrically with the rotor axis each of said stator unit consisting of two opposite stator cores having crawl poles extending axially on the inner peripheral surface thereof, and of one of three stator windings of U, V and W phases held between said two stator cores, said windings of U, V and W phases being arranged in this order in the axial direction, said crawl poles being separated by $180^\circ / M$ from one another and magnetized by said stator winding in opposite polarities alternately, said three stator windings being connected to form the star or delta connection, adjacent crawl poles magnetized by the stator windings of U phase and V phase are deviated by $120^\circ / M$ from each other in the circumferential direction, and

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adjacent crow poles magnetized by the stator
windings of V phase and W phase are deviated
by $120^\circ / M$ from each other in the
circumferential direction, each of said annular
stator windings having a center tap, said
annular stator windings being excited by a
unipolar circuit having six transistors so that
a magnetic flux generated by the excited annular
stator windings of one phase in the axial
direction becomes always opposite to that
generated by the excited annular stator
windings of other phase, in case of two phase
exciting driving.

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